

Report from the Management Working Group

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INTRODUCTION

The Management Working Group was given the following tasks to address:

- Evaluate existing legislation, regulations, statutes, management approaches, and conservation initiatives that apply to coral reefs in U.S. waters (State/Territorial/Federal), in other countries, and regional initiatives; their effectiveness at protecting these corals and enhancing recovery potential; and where they are being applied.
- Identify measures that would enhance compliance with existing measures.
- Recommend additional measures that could be implemented on a local, national, and regional scale that are necessary to address threats affecting these species and can help rebuild populations, and where these need to be applied.
- Identify approaches to enhance national and regional collaboration.
- Evaluate the benefits/drawbacks of an Endangered Species Act (ESA) listing, locations where this listing would be most effective, and the type of issues that the listing would have to address to mitigate threats.
- Identify information needed (research, monitoring, restoration, and so on) by resource managers that would help assist managers in protecting remaining corals and rebuilding populations.
- Examine the potential implications of not taking additional steps to conserve these species and the reefs where they occur.

The working group included experience in the following places: U.S. (Florida Keys and Biscayne Bay), U.S. Virgin Islands, Puerto Rico, and Trinidad and Tobago; this report reflects this participation and the Working Group recognized that additional input would be required to make this report more representative of the Caribbean region.

1. Evaluation of Existing Regulatory Framework and Measures to Enhance Compliance

The existing regulatory framework is substantial in the U.S. and many Caribbean nations. Fishery Management Plans, National Parks and Monuments, and National Marine Sanctuaries in federal, state and territorial waters of the Gulf of Mexico, West Atlantic, and Caribbean are examples of management measures that have been taken to both directly and indirectly protect corals. Of importance to *Acropora* populations, most managed areas in state and federal waters now prohibit take of stony corals. Some areas provide mooring buoys to minimize physical damage to corals from anchoring. Additional measures include prohibition of the use of fishing gear in no-take zones and regulations against any direct physical impact to corals.

These regulations are necessary, but not sufficient, to protect *Acropora*. Often existing protective measures are insufficient as they may include protective measures established in one particular location (e.g., state or federal waters), but they do not apply to adjacent areas. In addition, there often is a general lack of

political will and enforcement capacity. This is most often the case for many coastal zone issues, resulting in degradation of mangrove, seagrass, and coral reef habitats. A “common denominator” for these impacts is poor water quality, including elevated nutrient concentrations, persistently or periodically heavy sediment loads, and various chemical contaminants (e.g., pesticides, petroleum compounds, and mercury).

In this regard, we must enhance public education and outreach, including how land-based activities impact coastal zones. Another potential measure is through fortified penalty structures, which should enhance compliance and restoration of ecosystem structure and function. This is a necessary context for all other, more-specific steps toward *Acropora* restoration. There is a need to re-evaluate current systems of navigational aids (charts, markers, and education) because of the prevalence of boat and ship groundings in some areas. Because of the shallow depth distribution of *A. palmata* in particular and *A. cervicornis* in some cases, reef groundings often damage at least one of these species. Improved navigational aids may help prevent some of this kind of damage.

Some steps toward improving water quality have been taken in some areas, and degraded water quality is widely recognized as a management issue. For example, in the Florida Keys, State waters have been designated as a no-discharge zone and pump-out facilities are widely distributed for boaters to use. In addition, the city of Key West, which processes nearly half of the wastewater produced in the Keys, now uses advanced wastewater treatment and injects this highly processed effluent into a deep, confined aquifer. Finally, the State has strict regulations regarding shoreline development, which protects mangrove and other critical nearshore habitats including patch reefs.

The existing regulatory structure allows penalties and fines to be imposed on violators. This enforcement capacity can only be as successful as political will and available resources allow. In most of the region, political will and resources are lacking, particularly in areas where tourism-based economies or long-term subsistence fishing dominate decision-making and implementation of management plans.

Resolution: *The existing regulatory framework in the U.S. and its territories, as well as in many Caribbean nations offers limited protection to Acroporid populations through 1) the establishment of parks, sanctuaries, monuments, and reserves; 2) fishery management plans that limit or prohibit the take of corals; restrict the use of fishing gears that cause habitat damage and breakage of corals, especially in no-take reserves; 3) federal, state and territorial programs to establish and maintain mooring buoys to minimize coral breakage associated with anchoring; and 4) coastal zone management strategies that address shoreline development, sewage treatment and discharge, and destruction of associated habitats such as mangroves. However, the existing regulatory structure is insufficient for most Acropora populations; additional measures are necessary to improve water quality, address coastal development, improve navigational aids, address habitat damage from anchoring, destructive fishing gears, and boat groundings, and enhance enforcement.*

2. Evaluation of Existing Management Approaches and Conservation Initiatives in U.S. Waters.

The existing management approaches and conservation initiatives of most benefit to branching corals have focused on addressing physical impacts, including damage resulting from fishing gear, anchoring and ship groundings. Depending on zoning and regulations, marine protected areas (MPAs) help prevent damage from gear and groundings. Because all corals, particularly branching growth forms such as *Acropora*

palmata and *A. cervicornis*, are susceptible to such impacts, MPAs can afford some immediate protection from this type of damage. As noted above, enforcement capacity generally is lacking, which compromises a central function of zoning plans; many resource managers emphasize the need for strengthening enforcement capacity. When they are effective, marine reserves prohibit all collection of marine life and other resources, with the goals of protecting biodiversity and sensitive habitats, and restoring ecosystem processes.

1. Florida

The John Pennekamp Coral Reef State Park was established in 1960 as the first coral reef MPA world-wide. The area of protection in the Upper Keys was extended by implementation of Key Largo National Marine Sanctuary in 1975. The Looe Key National Marine Sanctuary (1981) protected a significant coral reef in the Lower Keys.

Three National Parks have been designated in South Florida marine environments. Dry Tortugas (DRTO; 1992) and Biscayne (BISC; 1980) National Parks include significant coral reefs. Prior to the establishment of DRTO, the Fort Jefferson National Monument (1935) protected the area. In addition, Everglades National Park (EVER; 1947) includes much of Florida Bay, an important subtropical lagoon with vital ecological connections with the Florida Reef Tract.

The U.S. Fish and Wildlife Service manages several large National Wildlife Refuges that protect extensive areas of shallow hardbottom and seagrass environments in the Lower Keys, which also have important ecological connections with the Florida Reef Tract. Additional MPAs are managed by the State of Florida.

The U.S. Congress designated the Florida Keys National Marine Sanctuary (FKNMS) in 1990. The FKNMS covers nearly 10,000 km² surrounding the Florida Keys and Reef Tract, and encompasses many of the management areas noted above. It took six years to develop a management plan for the FKNMS, including a multiple-use zoning plan with 23 fully protected (“no-take”) marine reserves. Another three years were required to develop a plan for the Tortugas Ecological Reserve, the largest marine reserve in the U.S. (518 km²). Approximately 10% of coral reef environments in the Florida Keys are protected within marine reserves.

Corals in general are afforded a number of mechanisms of protection under the various Action Plans that comprise the FKNMS Management Plan, but there are no particular programs for *Acropora* spp. In practice, however, *Acropora* spp. receive particular attention in the form of tight restriction on collection of samples for research and restoration after damage from boat groundings and other sources.

The Florida Keys comprise an Area of Critical State Concern, with a Rate-of-Growth Ordinance for growth management and support for implementing comprehensive wastewater and stormwater treatment plans.

Cable corridors are being implemented to minimize damage to corals off southeastern Florida. Additionally, county and state agencies require transplantation and monitoring of corals potentially affected by cable deployment and other reef altering activities.

Additional protective measures include a 1990 designation of *Areas To Be Avoided* by ships longer than 50 m. Coincident with this step was a dramatic decline in large-vessel groundings in the FKNMS. The Florida Reef Tract, which lies within the sanctuary, is marked by eight RACON beacons, which transmit warnings to ship radar screens. The FKNMS also has an active program for waterway markers and maintains more than 400 mooring buoys, which help minimize anchor damage. Regulations are enforced by 17 officers equipped with vessels up to 82' in length, which supports cruises to the relatively remote Tortugas region. Finally, the FKNMS has an active program of education and outreach, which includes volunteers and staff (Team OCEAN) who provide boaters with information at sea.

Seven reefs dominated by *Acropora cervicornis* occur in nearshore waters off Fort Lauderdale. These reefs are being closely monitored, but have not been provided with particular protective measures.

2. U.S. Virgin Islands

Virgin Islands Coral Reef National Monument (VICR) was recently created and Buck Island Reef National Monument (BUIR) was recently expanded by the designation of thousands of acres of non-extractive zones (2000 Executive Order). These new and expanded National Monument designations afford total protection to 7% of the St. Croix shelf and 3% of the St. John/St. Thomas shelf. In December, 2002, the Virgin Islands Legislature passed Bill 12 approving establishment of the St. Croix East End Marine Park.

A program of mooring buoys managed by the National Park Service, non-governmental organizations (NGOs), and private dive operations provides additional protection from anchor damage to coral reef ecosystems including seagrass beds. In addition, a vessel management plan regulates numbers of vessels and uses allowed in Virgin Islands National Park (VIIS) waters. Thirteen Areas of Particular Concern, mostly including marine environments (particularly St. Croix coral reefs), are part of a Territorial zoning plan that theoretically should manage development to be environmentally sustainable.

The St. Croix petroleum refinery has an oil spill response team involving resource managers to help guide appropriate response strategies. Environmental Sensitivity Index maps (NOAA/U.S. Coast Guard) delineate coral reefs and other sensitive habitats and resources that could be impacted by an oil spill.

The Coastal Barrier Resource Act identifies sensitive areas such as coral reefs. There are 30 sites in the USVI that are designated as federal coastal barriers. This designation provides protection from development with federal funding or requiring federal action.

3. Puerto Rico

In Puerto Rico there exist several laws and proposed regulations that may aid in the conservation of corals. The most pertinent statute is the Law for the Protection, Conservation, and Management of Coral Reefs in Puerto Rico, Law 147. This law explicitly mandates the conservation and management of coral reefs in order to protect their functions and values. The Department of Natural and Environmental Resources (DNER), the agency in charge of implementing the law, will do so through a regulation that is currently being prepared. Law 147 provides for the creation of zoned areas in order to mitigate impacts from human activities. These zones include (1) Reef Recuperation Areas and (2) Ecologically Sensitive Areas. These zones will facilitate the DNER in controlling human activity that can directly impact *Acropora* spp. such as anchoring. Law 147 also directs the DNER to identify and mitigate threats to coral reefs from degraded water quality due to pollution. Law 147 will also require an Environmental Impact Statements (EIS) for projects or activities that can negatively affect coral reefs.

DNER is currently developing regulations to begin implementing Law 147. An interagency committee will be convened to coordinate government activities that may affect coral reefs.

Law 137 from 2000 directs the DNER to designate priority areas as marine reserves, including a minimum of 3 percent of the insular platform within 3 years (2003). Marine reserves are defined as areas where all extractive activities are prohibited in order to help recover depleted fishery resources and protect biodiversity, and can protect *Acropora* by preventing impacts from fishery gear. To date, two marine reserves, Reserva Natural Canal Luis Peña in Culebra, and Desecheo Island have been established.

There are also currently 13 natural reserves in Puerto Rico that have coral reefs within their boundaries. These are managed by the Puerto Rico Department of Natural and Environmental Resources (DNER). The Reserves are located on all coasts and offshore islands and provide an infrastructure for management measures to protect *Acropora* spp. populations. The DNER has been utilizing mooring buoys since 1990, principally in the Natural Reserves in Fajardo, Culebra, Guánica, and La Parguera. More information is needed on the location and status of *Acropora* spp. populations within the natural reserves in order to apply the conservation strategies, particularly those pertaining to direct impacts. It should be noted that natural reserves probably have minimal success in preventing impacts to coral reefs and *Acropora* spp. from degraded water quality because these impacts are not excluded by reserve boundaries.

Resolution: *A variety of protected areas exist in Florida, USVI and Puerto Rico, including National Monuments, Sanctuaries, Reserves, and Wildlife Refuges. These and other areas are typically zoned for specific or multiple uses and often include no-take areas and offer various protective measures such as a prohibition on extractive activities. However, in general, they encompass a relatively small portion of the total Acropora habitat, they offer limited protection from various environmental impacts such as degraded water quality, and enforcement may be limited or lacking.*

3. Proposed New Initiatives for U.S. Reefs to Enhance Protection of Coral Reef Resources

While the nature and magnitude of human impacts to coral reefs vary among reefs and jurisdictions, many of the underlying activities are authorized and regulated under law and can be managed or mitigated using existing federal and state authorities, with programs tailored to local needs. Through the U.S. Coral Reef Task Force, federal and state agencies have agreed to pursue a comprehensive program focused on nine conservation strategies designed to reduce or eliminate the most significant threats to coral reefs. These include: 1) expansion and strengthening of marine protected areas; 2) reduction of impacts from extraction; 3) reduction of habitat destruction; 4) reduction of marine and land-based pollutants; 5) restoration for damaged reefs; 6) reduction of global threats; 7) reduction of impacts from international trade; 8) improved interagency accountability and coordination; and 9) expanded education and outreach for the public.

Many of the chief threats to coral reefs stem from human activities taking place on or near specific reef tracts. One of the most promising conservation tools to address these are marine protected areas that encompass and protect important habitats where harmful activities can be minimized through a system of marine zoning. Among the various types of MPAs, ecological reserves, or no-take zones, are particularly effective in maintaining biodiversity, productivity and ecological integrity, and for *Acropora* habitats may be most useful in protecting these corals from damage associated with particular types of fishing gear, anchoring

and other physical stressors. Although a number of MPAs currently exist, there are multiple problems associated with these, including: 1) considerable gaps in coverage; 2) gaps in protection within existing sites; 3) limited degree of connection among protected areas; 4) designation and management under multiple jurisdictions (state, federal, territorial, local jurisdictions) with differences in purpose, scope and authority under each jurisdiction; 5) limited international cooperation; and 6) lack of consistent definitions to describe various levels of protection.

The U.S. Coral Reef Task Force has proposed a critical marine conservation goal for MPAs in the U.S. that includes 1) strengthening of protection within existing MPAs; 2) establishment of additional no-take ecological reserves with a goal of 20% of all representative U.S. coral reefs and associated habitats by 2010; 3) a national assessment of the remaining gaps in coverage; and 4) strengthened support for international cooperation to conserve global biodiversity.

Among U.S. Jurisdictions, proposals to strengthen existing MPA structure and develop new MPAs include:

1. Dry Tortugas National Park

The Park has proposed to implement a Research Natural Area (marine reserve) that would cover an area of approximately 158 km², including significant shallow coral reef environments.

2. U.S. Virgin Islands

The creation of the Virgin Islands Coral Reef National Monument (VICR) and the enlargement of Buck Island Reef National Monument are very significant for coral reef and associated habitat protection. Both monuments are awaiting a final review by the Government Accounting Office (Congress) before management actions can be implemented. VIIS will be developing a new General Management Plan in 2003, which will implement additional coral reef protection measures. VICR is also proposing to install a hurricane mooring system in Hurricane Hole that will protect the mangrove and coral communities from vessels using this area as a storm refuge.

The Territorial government is moving forward on the establishment of the East End Marine Park in St. Croix. This park will contain several no-take zones and coral resources in all zones will be protected.

There are a number of other marine reserves in the USVI that are basically “paper parks” because of lack of enforcement. Steps to take include educating residents and visitors, enforcing regulations, and employing more enforcement officers.

3. Puerto Rico

Law 137 from 2000 directs the Puerto Rico DNER to designate priority areas as marine reserves. Marine reserves are defined in this statute as areas where all extractive activities are prohibited in order to help recover depleted fishery resources and protect biodiversity. The law states that that three percent of the insular platform must be designated within 3 years (2003). This mechanism could be helpful in the conservation of *Acropora* spp. if it is determined that overfishing of coral reefs that is affecting survivorship of these corals. It has been hypothesized that overfishing of reef fish, octopus, and lobster may lead to an increased abundance of *Acropora* spp. predators such as the snail *Coralliophila abbreviata*. Currently

there are two marine reserves in Puerto Rico, Reserva Natural Canal Luis Peña in Culebra and Desecheo Island. However, these two reserves only protect a very small percentage of the *Acropora* spp. populations in Puerto Rico.

Resolution: *Over the last five years Florida, USVI, and Puerto Rico have made major conservation advances through the establishment of various types of marine reserves and proposals for new marine protected areas. Many of these have been established in coordination with initiatives to address habitat destruction through limitations on the use of destructive fishing gear, installation of mooring buoys and navigational aids, no anchoring zones, improved wastewater treatment, and other measures.*

4. Additional Measures Needed on a Local and National Scale

A. Strategies to address overfishing and fishery gear impacts

Strategies to address overfishing in coral reef ecosystems are necessary to mitigate problems associated with macroalgae abundance and cover, growing populations of corallivores, and other problems. Overfishing of herbivorous parrotfish and surgeonfish has contributed to increases in macroalgae, which may overgrow stony corals and can lead to reduced potential for recruitment of planula larvae. Also, removal of certain predatory fish such as groupers may contribute to an increase in three spot damselfish populations, which can further contribute to the loss of *Acropora* through the creation of algal gardens. Overfishing of a number of other invertebrate and fish species, such as lobsters, octopus, trunkfish and hogfish, may result in greater numbers of coral eating snails, and increased mortality to *Acropora*.

1. Florida

There needs to be considerable thought and discussion about reductions in fishing effort, such as a program to invest in reducing fishing fleets.

Further programs of outreach and education could be developed to better inform the public and decision-makers about how overfishing affects the condition of coral reefs and steps they can take to help improve the protection and conservation of coral reef ecosystems. We need to be more effective at communicating how marine reserves protect populations and habitats.

Penalties could be made more severe and additional resources could be directed toward enforcement. Penalty structures could be modified to include the rescinding of fishing permits and/or the confiscation of gear and vessels.

More marine reserves could be designed, discussed, and implemented, and the size of existing reserves could be increased. Communities and residents should take more of a “stewardship” approach to local waters and the resources they contain.

2. U.S. Virgin Islands

Overfishing is a large concern. It is necessary to enforce existing regulations, eliminate fishing in protected areas, protect spawning sites, and protect nursery habitats.

Losses of mangrove habitat exacerbate problems associated with overfishing. There is a pressing need to protect mangroves, which are already a protected species under VI law; control water quality in mangrove areas; re-site or replace aging sewage treatment systems; and enforce the use of vessel pump-out facilities and provide additional facilities.

3. Puerto Rico

There is widespread recognition of overfishing within Puerto Rico's nearshore coastal communities, especially among coral reefs. The concerns extend to both recreational fisheries and commercial fisheries, and also among certain types of destructive fishing gear (traps and gill nets). In addition, local fishers target lobsters and octopus in shallow water, often wading through and damaging *Acropora* habitat in the process of collection. A number of reef fishes and invertebrates that may be important in controlling corallivorous molluscs are presently overexploited, including lobster, octopus, trunkfish, hogfish and other species.

Puerto Rico, through DNER, has developed a new coral reef fisheries law and is currently developing regulations (Reglamento de Pesca de Puerto Rico). These will establish a variety of new measures, including restrictions on gear types, locations of fishing areas (and areas closed to fishing), permits for harvest, sizes, seasons and/or quotas for the harvest of commercially important species, and provisions for licensing. If adopted, these regulations will also prohibit spearfishing.

Resolution: Coral reefs and associated habitats provide fishery resources that represent a critical source of food, but increased rates of collection and associated habitat destruction are threatening the regenerative capacity of these species and critical linkages among species and in some cases are contributing to phase shifts. A number of management initiatives have been proposed including improved monitoring and protection for fishery resources; greater habitat protection through establishment of no-take MPAs and other efforts; measures to protect spawning populations; elimination of destructive fishing practices and gears; implementation of gear restrictions; and incorporation of ecosystem-scale considerations in Fishery Management Plans.

B. Diseases and predation

Although white-band disease, white pox, and other syndromes are recognized as important sources of mortality to elkhorn and staghorn coral, scientists and managers have very little information on the epizootiology and etiology of these diseases. Greater emphasis needs to be placed on 1) field monitoring programs to determine the temporal and spatial distribution, abundance and impact, and synergistic effects of other natural and anthropogenic stressors; and 2) laboratory studies to determine causative agents, role of other stressors in the proliferation and spread of these diseases, and host response. With this information, scientists and managers can begin to work toward the development of strategies to mitigate diseases, possibly by treating diseased colonies, addressing water quality issues and managing possible vectors for disease transmission. In addition, efforts are needed to determine whether there are disease resistant clones.

The recognition of significant predation by invertebrates and fishes has been acknowledged for Caribbean Acroporids primarily when coral prey abundance was diminished by other factors, and possibly in response to increased densities of predators. We need further research on corallivores such as *Coralliophila* and *Hermodice* and on the damaging effects of *Stegastes planifrons* algal-gardening behavior. Research is needed to help determine the efficacy of programs of *Coralliophila* and *Stegastes planifrons* control. In particular, managers need more information about the predators of these three species and other possible mechanisms for population controls. Small-scale corallivorous snail removal in remnant *Acropora palmata* populations undertaken in the Florida Keys was effective in preserving live tissue, but it is unclear whether this is an effective management strategy at a larger scale and the ramifications of such a manipulation in a complex coral reef community remain unknown.

Management strategies should include training programs to heighten awareness and alert resource managers of infestations and acute changes in reef communities. Any such efforts should be conducted as step-wise approaches in a plan for ecosystem restoration: action, result, and end product.

Resolution: *Coral diseases and coral predators need far more study. Managers need to know the causes of diseases affecting Acroporids, how diseases are transmitted, and any actions that can be taken to reduce their negative impacts on Acropora populations. Efforts should be made to determine the degree of disease resistance that exists among clones and genetic mechanisms for resistance. Research is also needed to determine the efficacy of programs to control pest species such as Coralliophila abbreviata and Stegastes planifrons*

C. Pollution and sedimentation

Excessive sedimentation generated by coastal development, agriculture and dredging, increased nutrients from agriculture, sewage discharge and fertilizers, and discharge of oils and chemicals disrupt normal biological and ecological processes, kill benthic invertebrates, and artificially encourage growth of macroalgae. Acroporids are particularly sensitive to poor water quality, as they have a poorly developed mechanism to remove sediment from their branch surfaces and they require high light levels for photosynthesis.

1. Florida

There need to be increased non-point source pollution controls to reduce or eliminate upland sediment impacts to nearshore coral reefs, e.g., pave roads, construct sediment catchment basins, and utilize proper site drainage.

Given the recent designation of State waters as a no-discharge zone, expansion of this designation to include Federal waters (40% of the Sanctuary) has been proposed. Sanctuary staff are developing steps to protect and culture fragments of *Acropora* spp. rescued from boat-grounding sites and other damaged areas. They are exploring partnerships for the rehabilitation of coral fragments for future use in reef restoration projects. The Florida Keys has a Wastewater Treatment Master Plan that comprehensively defines future needs for treatment systems. This plan is being implemented, and a test project in one municipality will generate data on changes in nearshore water quality that result from the conversion from on-site sewage disposal systems (e.g., septic tanks and cess pits) to centralized treatment facilities.

2. Puerto Rico

Sedimentation and pollution are of growing concern to Puerto Rico's nearshore reefs. Law 147 directs the DNER to identify and mitigate threats to coral reefs from degraded water quality due to pollution.

Resolution: *Pollution and sedimentation could be significantly reduced by fully implementing existing authorities among various federal, state and territorial agencies, but this will require greater efforts to monitor existing water quality, expanded studies to determine the ecological relevance of various pollutants, and improved permitting mechanisms for development projects that affect coral reefs. Local partnerships among governments, land owners, industry and the public are necessary to implement measures to reduce land-based runoff and prevent discharge from known point sources.*

D. Reduce physical impacts to coral populations from anchoring and ship groundings

1. Florida

In 1997, NOAA designated Tortugas Bank as a no-anchoring zone for ships at least 50 meters long, however, foreign-flagged ships carrying international (non-NOAA) charts did not show this zone. In May 2002, the International Maritime Organization adopted a proposal to designate areas around the Florida Keys as a Particularly Sensitive Sea Area (PSSA). As one of the only PSSA's in the world, this designation (effective Dec. 1 2002) will increase compliance with no anchoring and reduce the threat of groundings and spills.

Using vessel-grounding data from the Florida Keys National Marine Sanctuary, the U.S. Coast Guard installed new markers at a hard-hit shallow reef historically dominated by *Acropora palmata*.

E. Captive breeding programs and coral restoration approaches to rebuild *Acropora* populations

Captive breeding is a possible approach toward helping to rebuild *Acropora* populations. Aquarists have developed techniques to successfully maintain and propagate scleractinian corals in closed systems, and Acroporids are particularly amenable to culturing in grow-out systems placed on the sea floor. Some of the major concerns, that need to be evaluated from a management perspective, include sources of fragments for grow-out, impact of culturing on genetic diversity, and possibility of reestablishing Acroporid populations in degraded areas using cultured branches and colonies.

It is necessary to improve response and success of vessel grounding restoration projects through development of standard assessment procedures, notification protocols, and restoration approaches. Base resources should be available to respond and react to catastrophic injuries. Volunteer programs can provide assistance in the rescue, re-stabilization, and monitoring of injured coral colonies.

Restoration projects should be conducted using a hypothesis driven scientific approach whenever possible. Coral restoration is a relatively new approach to ecosystem management and is still in its infancy in regards to methods and strategies. We have much to learn about the best methods and substrata for reattachment of fragments produced by groundings, storms, and other events. For *Acropora*, a variety of approaches to stabilize fragments have been undertaken, ranging from reattachment using cement, epoxy, wire, and cable ties, however, cost and benefits of these approaches has not been evaluated. Development of successful methods should be done through designed experimental approaches that will allow for better decision making and project design.

Restoration projects should be monitored in ways to help inform management actions. Numerous restoration projects have been undertaken and can provide valuable information through long-term monitoring efforts, yet the outcome of these efforts is rarely reported. Monitoring projects should be designed to answer fundamental questions about the project's success as a function of the ecosystem as a whole.

1. Florida

Several restorations in response to ship groundings have been undertaken in Florida, including groundings within *Acropora* habitat. To date, three of these have involved stabilization and reattachment of branches/colonies. A small-scale effort involving *A. palmata* was undertaken by the FKNMS in collaboration with Reef Relief, in which storm-generated *Acropora* branches were attached to cement rosettes placed in shallow water. Fragments generated by storms and from ship groundings are also being cultured by various laboratories, including Mote Marine Laboratory and the Florida Aquarium in Tampa.

2. Puerto Rico

A biological restoration following the grounding of the Fortuna Reefer vessel was undertaken off the east coast of Mona Island in 1997. A total of 1857 *A. palmata* branches were secured to reef substrate and to dead, standing *A. palmata* skeletons using stainless steel wire. In 2000, a mid course correction was undertaken, where surviving fragments were re-wired with heavy stainless wire and a small subset were also secured using cement. NOAA Fisheries has been monitoring the success of this effort.

In southwest Puerto Rico, a small NGO formed by University of Puerto Rico graduate students is propagating *A. cervicornis* fragments by attaching small branches to wire racks and growing these out in shallow reef sites. Fragments are collected from different reefs and reef zones, in attempt to maximize genetic and environmental variation. Pilot studies have been highly successful with high survivorship, rapid growth rates, and the enhancement of localized fish populations through creation of high relief substrate in non-coral areas. However, additional research and small-scale projects are needed to help determine whether this approach can be utilized on a large-enough scale to be of use to managers.

3. U.S. Virgin Islands

A small coral transplant project utilizing *Acropora palmata* and *A. cervicornis* is underway in the Virgin Islands National Park. The researchers are using cable ties to fasten naturally-occurring fragments of three fast growing species of coral to damaged reefs.

Resolution: *Coral mariculture and aquaculture and other propagation techniques, along with transplantation, and reattachment of dislodged Acropora fragments, may provide a feasible strategy to rebuild degraded Acropora populations. These efforts may be especially useful in areas for which natural recovery is unlikely (due to an absence of parent colonies or sexual recruits), and on a small scale to speed up recovery following a ship grounding. However, care must be taken to ensure that source coral populations are not degraded, genetic diversity is maintained, and potential introductions of pathogens or other invasives are avoided. In addition, restoration efforts should not be undertaken unless the source of the threat has been identified and addressed. Because we know very little about appropriate restoration strategies and potential long-term benefits, all restoration efforts should be undertaken using an experimental approach that includes measures to evaluate the success.*

5. Evaluation of Management Measures Outside U.S. Waters

Any efforts to protect Acroporid coral populations in the U.S. would benefit from measures adopted in other countries, as coral populations are likely to be linked through sexual reproduction and dispersal of planula larvae. Measures proposed or existing in U.S. waters, including MPAs, Fishery Management Plans, and improved Coastal Zone Management strategies, also need to be implemented outside of the U.S. Also, new information on approaches to understand and address various stressors and enhance recovery of coral populations through propagation, transplantation and other ecological and biological restoration approaches should be shared with other countries.

Through a brief evaluation of existing measures outside of U.S. waters, protected areas were recognized as one of the key areas of emphasis; many countries have established MPAs, but these vary in scope, size and success. Also, a variety of fishery management strategies have been adopted, but there is a general consensus that greater emphasis needs to be placed on sustainable management of commercially important food fish and ornamental species. Perhaps one of the most widespread initiatives, most countries have implemented a system of mooring buoys to reduce anchor damage.

A number of limitations with existing management mechanisms were identified. Most importantly, in many cases management plans have been developed but not implemented; habitat destruction is occurring as a result of harmful fishing gears, dredging, and removal of mangroves; existing regulations are insufficient and protected areas are offered very limited protection due to a lack of enforcement capabilities; and strategies to address water quality need to be improved. Finally, it was noted that the agencies that have authority to address the most critical needs for *Acropora* often involve different branches of the government, and more cooperation between various regulatory agencies is critical.

Resolution: *A number of countries have taken key steps to protect coral reef ecosystems within their waters through the development of MPAs, implementation of Fishery Management Plans, and development of strategies to address water quality issues. However, these efforts need to be greatly expanded on a local to regional scale and substantial new initiatives are necessary. There is a need for improved sharing of information and technical assistance from the U.S.; greater efforts to educate the public and user groups regarding the importance of coral reef ecosystems, threats, and solutions; and better cooperation among different government agencies, non-government organizations, industry and the public.*

6. Regional and Global Initiatives

A. Regional organizations

Regional organizations exist such as CaMPAM, a network for MPA managers in the Caribbean region. However, groups such as this generally lack funding and leadership. There is a need to get upper management of local conservation efforts more engaged in such regional-scale programs.

1. Coastal and Marine Productivity Networks (CARICOMP) and Atlantic and Gulf Rapid Reef Assessment (AGRRA)

CARICOMP and AGRRA have been contributing to a better understanding of the status of Caribbean Acroporids through their monitoring programs. Through their efforts we have been able to get recent

information from close to half of all Caribbean nations. These efforts should be supported and expanded to enhance collection of data on the status and trends of these corals from throughout their range.

2. Specially Protected Areas and Wildlife in the Wider Caribbean Region (SPAW) protocol

The SPAW Programme supports activities for the protection and management of sensitive and highly valuable natural marine resources. This program is responsible for the regionalization of global conventions and initiatives such as the Convention on Biological Diversity (CBD), the International Coral Reef Initiative (ICRI), and the Global Coral Reef Monitoring Network (GCRMN). The goals include efforts to: 1) significantly increase the number of and improve the management of national protected areas and species in the region, including the development of biosphere reserves, where appropriate; 2) to develop a strong regional capability for the coordination of information exchange, training and technical assistance in support of national biodiversity conservation efforts; 3) to develop specific regional, as well as national management plans for endangered, threatened or vulnerable species; and 4) to coordinate the development and implementation of the Regional Programme for Specially Protected Areas and Wildlife in the Wider Caribbean, in keeping with the mandate of the SPAW Protocol.

B. International Protection

1. CITES

All stony corals are currently listed on Appendix II of the Convention on the International Trade in Endangered Species (CITES). This listing is designed to prevent the overexploitation of stony corals as a result of international trade by requiring that exporting countries issue permits for the trade in corals. These permits must include a finding that the species in trade was legally acquired and the trade in that species is not detrimental to the survival of the species in the wild. This listing does not offer protection for corals that are in domestic commerce.

2. International Maritime Organization

The delicate coral reefs along the Florida Keys have become the first internationally protected nautical zone in the United States. The 2,900-square-nautical-mile zone is designed to protect fragile coral from anchors, groundings and collisions from large international ships. The zone stretches from Biscayne National Park to the Dry Tortugas and encompasses all of the 2,500-square-nautical-mile Florida Keys National Marine Sanctuary. Future nautical charts are expected to show the zone, known as the “Florida Keys' Particularly Sensitive Sea Area”.

Resolution: *Several regional and international fora, including CaMPAM, SPAW, ICRI, GCRMN, CITES, AGRRA and CARICOMP are available to assist in the regional and international protection of Acroporid corals through improved management, monitoring, and conservation. However, there are various limitations with several of these initiatives, such as funding and leadership problems, a capability to adopt measures that address important concerns but not necessary the most critical concerns for these species, or limited public, government and/or industry support.*

7. Potential Benefits and Drawbacks of ESA Listing

Threats to Acroporid corals pose difficult management problems that are currently addressed through a patchwork of federal, state and territorial regulatory and management programs. The most important programs involve managing state and federal parks, marine sanctuaries, commercial fisheries, offshore mineral development, and coastal zone development. In most cases, these efforts have been developed independently of one another, and they reflect strategies to protect certain areas, to conserve certain species or to provide broad protection. While existing programs provide meaningful and necessary protection, these programs have offered very limited protection for Acroporids, they have not always addressed management needs from an ecosystem perspective, and they have not adequately addressed priority conservation issues for these species.

A. Potential benefits of ESA listing include:

The ESA provides a means for conserving species that are threatened or in danger of extinction, and for the conservation of the habitats upon which those species depend. Once listed, the ESA mandates implementation of a recovery program capable of restoring a species in its natural habitat to a level at which it can sustain itself without further legal protection. The goals of the recovery program are to 1) identify the ecosystems and organisms that face the highest degree of threat; 2) determine actions necessary to reduce or eliminate the threats; and 3) implement strategies to recover the species.

Threatened species designation for *A. palmata* and *A. cervicornis* would result in a population-by-population approach to protection through critical habitat designations, with stronger penalty structures. Critical habitat designations could in turn be used to help improve water quality through a ridge-to-reef approach to improved coastal zone management, e.g., protection of mangrove, seagrass, and coral reef habitats.

Some other specific benefits of an ESA listing include:

- Critical habitat designation – protection and enforcement for areas occupied by *Acropora* as well as habitats essential to the survival of these species (e.g., associated mangroves and sea grass beds).
- Captive breeding through implementation of a recovery plan - scientific efforts to understand and improve mariculture, transplantation and other restoration approaches may be supported as a key strategy to rebuild populations.
- Increased attention and awareness – an ESA listing would focus attention on coral reefs, specifically Acroporid corals, raising awareness among public, legislators, and other public officials.
- Increased research funding- through development of a recovery plan one of the goals may be support for targeted research leading to an improved understanding of *Acropora* biology.
- Increased protection for all coral reef species - by protecting declining coral species such as *A. cervicornis* and *A. palmata* through the ESA, other species assemblages dependent on reefs will also benefit.

- Reduce impacts to *Acropora* habitats from development or dredging - Prevents projects funded, authorized or carried out by the Federal government if those activities would contribute to the degradation of habitat occupied by the species.
- Copy-cat effect- through an ESA listing, greater recognition may be raised for the protection of other key invertebrate species that are also declining.

B. Potential drawbacks of an ESA listing include:

- Enforcement of incidental damage would be difficult
- Additional steps for researchers to obtain permits
- Draws more attention to species
- Section 7 consultative requirements for any impacts
- Difficulty of defining “take”
- Captive breeding/aquaculture

7. Implications of Not Taking Additional Steps

There are numerous strategies that are needed to protect coral reef ecosystems and many of these can be implemented under existing authorities. However, no single mechanism is likely to be sufficient to halt the decline of these corals and enhance their recovery. It is likely that managers will have to apply all of their tools to ensure recovery of these species, including application of the ESA. An ESA listing as threatened or endangered would require the development and implementation of a recovery plan thereby reducing the likelihood of extinction by alleviating threats affecting these species and promoting strategies to increase population size.

Acropora palmata and *A. cervicornis* are the fastest growing framework-building corals in the Caribbean. Their demise over the past 10-20 years likely has resulted in reef erosion rates that exceed accretion. This, in turn, can lead to:

- Loss of shoreline protection
- Habitat and biodiversity loss
- Declining tourism as reefs lose structure and associated animals

Another implication of not taking additional steps for *Acropora* is that we may soon be faced with the next group of species that are rapidly declining from similar threats— *Montastraea* – the second-most important genus that has built Caribbean reefs for the past million years.

Resolution: *An ESA listing would provide additional necessary conservation mechanisms, above and beyond the existing tools available to resource managers, to protect and restore these species while providing added benefits for associated species; it would provide for increased recognition and awareness of coral reefs, their importance and their vulnerable condition; and it would enhance our ability to fill information gaps through support for targeted research and monitoring. An ESA listing would also add additional burdens and costs for increased management, enforcement and permitting of activities. No single mechanism is likely to be sufficient to halt the decline of these corals and enhance their recovery. It is likely that managers will have to apply all of their tools to ensure recovery of these species, including application of the ESA.*

8. Additional Information Needs of Resource Managers

There is a critical need for standardization of collection, interpretation, and presentation of information. This standardization is necessary for direct comparisons of information from different sites, particularly ecological data.

A. Settlement and recruitment of Acropora

Resource managers need a better understanding of factors determining successful settlement and recruitment of *Acropora*. It is fairly well established that an intermediate level of grazing by *Diadema* results in higher densities of coral spat, and it would be helpful to determine whether this is the case for *Acropora*. Ongoing research by Drs. Alina Szmant and Margaret Miller may help answer this question. Research by Dr. Bob Steneck has showed that a particular species of coralline red algae attracts a number of different coral spat in the Indo-Pacific. This alga occurs in the Caribbean, but we do not know whether this same effect occurs generally and for *Acropora* in particular.

B. Genetic linkages of populations

Metapopulation genetics of *Acropora* is a final topic in need of further research. There is an ongoing study of *A. palmata* in the Florida Keys and this is an area that recently has gained far more attention by scientists.